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DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DIVISION, GREAT LAKES AND OHIO RIVER
CORPS OF ENGINEERS
P.O. BOX 1159
CINCINNATI, OHIO 45201-1159

CELRD-PD

Regulation
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LRD Navigation Locks and Dams Maintenance Standard

Appendix C

Process for Identifying Impact and Maintenance Priority for Navigation Locks and Dams

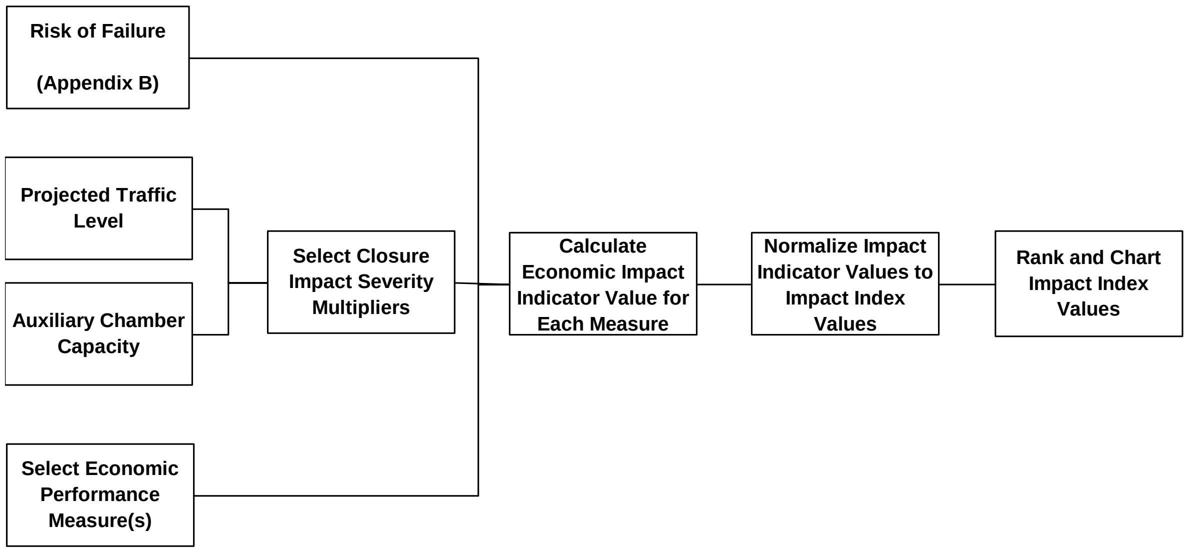
1. Purpose. The purpose of this Appendix is to describe a simplified procedure to be used to estimate the potential economic impacts of unscheduled lock chamber closures. This information can then be used by the District Navigation Maintenance Program Managers (DNMPM) for annually prioritizing the use of fleet maintenance packages to minimize, as best as possible, the economic impacts of unscheduled closures in the Division. Lock chamber closures (scheduled or unscheduled) impact commercial navigation by either halting all traffic, in the case of a single chamber facility, or increasing processing and queue delays, in the case of a multi-chamber facility. An aging Division infrastructure and limited Division resources requires that maintenance be focused first at those projects that exhibit the highest potential economic risk. A distinction is made here between failure risk and economic risk. The Division is not necessarily interested in minimizing unscheduled closures (maximizing reliability), but is most interested in minimizing the consequences of unscheduled closures. A moderately reliable lock processing tens of millions of tons annually probably should receive maintenance priority over an unreliable tributary lock that processes no commercial traffic, despite the fact that this tributary lock closes frequently, the consequences of failure and closure of the other project is much more severe.

2. Methodology Overview. It is recognized that the economic impacts of a closure can be quite complex. Economic impacts are shipper shipment specific and are sensitive not only to whether the closure occurs at a single or dual lock chamber facility, but also to the duration of the closure event. While the science has been advanced to estimate queue lengths and the hours of additional delay closures generate, quantification of the externalized costs are typically only captured through postmortem surveys. The costs from the ripple effect of trapped waterway transportation equipment, overland diversion costs, overland diversion impacts (delays, pollution, etc.) and regional impacts of missed or delayed shipments (layoffs, plant closures, etc.), is beyond the scope and expectations of this regulation.

The method described in this Appendix combines three factors related to navigation locks to help the DNMPM prioritize fleet maintenance packages throughout LRD: 1) risk of unscheduled lock chamber failure; 2) potential severity of the failure; and 3) a measure to gauge the potential economic impact of the failure. This process was developed using readily available information and an easy to use and understand methodology. As such, it does not claim to be an exhaustive engineering risk assessment or NED economic analysis. This method seeks to add a measure of objectivity to what was once a purely subjective process. Areas where this method is known to fall short of the ideal will be qualified with the term **Caveat** in bold text.

Although this Standard recognizes that these procedures will likely evolve over time as they are used and improved, as of the date of this Standard, the method should be interpreted as operating as shown in **Figure C-1**.

Figure C-1 Methodology Flow Chart



Each year, five tasks will be performed to prepare for application of this method:

a. for every main lock chamber in LRD, the risk of an unscheduled closure will be estimated in accordance with the procedures described in Appendix B;

b. for every lock in LRD, the projected traffic level will be estimated in accordance with the most recent traffic projections maintained by the USACE Center of Expertise for Inland Navigation (PCXIN);

c. for every auxiliary lock chamber in LRD, auxiliary chamber capacities will be updated in accordance with capacity data developed and maintained by the PCXIN. For locks that have only one chamber, this capacity will be zero. For locks with two chambers, this capacity will be the capacity of the auxiliary chamber. For locks with three chambers, such as Marmet or Winfield, this capacity will be equal to the capacity of the two old chambers operating together. However, it should be recognized that these old chambers may not be fully operable and the capacity adjusted accordingly;

d. appropriate economic performance measures will be selected by the PCXIN and the LRD Chief of Operations;

e. based on projected traffic levels and auxiliary chamber capacity, the PCXIN and LRD Chief of Operations will select closure impact severity multipliers.

For each lock, the risk of failure, expressed as a percent chance of failure, closure impact severity multiplier, and selected economic performance measure are then multiplied together to get an economic impact indicator value for the selected economic performance measure. The economic impact indicators are then normalized using a technique described in Section 6. This normalization process results in impact index values for each performance measure. The relative priority of each project can then be determined by ranking the projects from highest to lowest impact index value. The normalized impact index values for two or more economic performance measures can be averaged to arrive at a multiple measure ranking, if desired.

3. Risk of Failure. Appendix B describes the procedure which shall be used to determine risk of failure. **Caveat:** During a feasibility level risk assessment formal analytical procedures would be used to develop each risk probability. When this Standard was developed, such analytically developed risk values were not available for all locks in LRD. Therefore, we recognize the risk determinations will necessarily be expert elicitation based. **Additional Caveat:** It is recognized that two failure risk probabilities should be developed, one for the pre-maintenance condition, and one for the post-maintenance condition. The difference between these risks would be risk reduction and would be reflected in the next FY analysis if the maintenance reduced the lock's failure risk.

4. Closure Impact Severity Multipliers. If a failure occurs, the severity of the disruption depends on two factors, the ability of the facility to process traffic in a failed condition, and the duration of the failure. **Caveat:** When this Standard was developed, a good method for dealing with closure durations was not available. The LRD Chief of Operations indicated that those evaluating the fleet packages would recognize that the consequences of some failures cause longer closures than other failures, and they could take the duration into account during their deliberations. Therefore, as of the date of this Standard, closure duration is not part of the analysis.

Consider **Figure C-2** which shows the relationship between average transit time per tow and tonnage processed. This chart is applicable to Ohio River dual chamber locks. It shows how severely capacity is decreased if the main chamber is closed.

Figure C-2

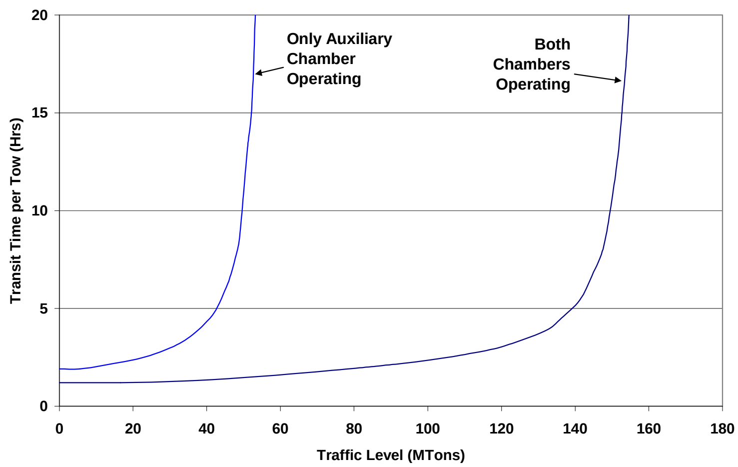
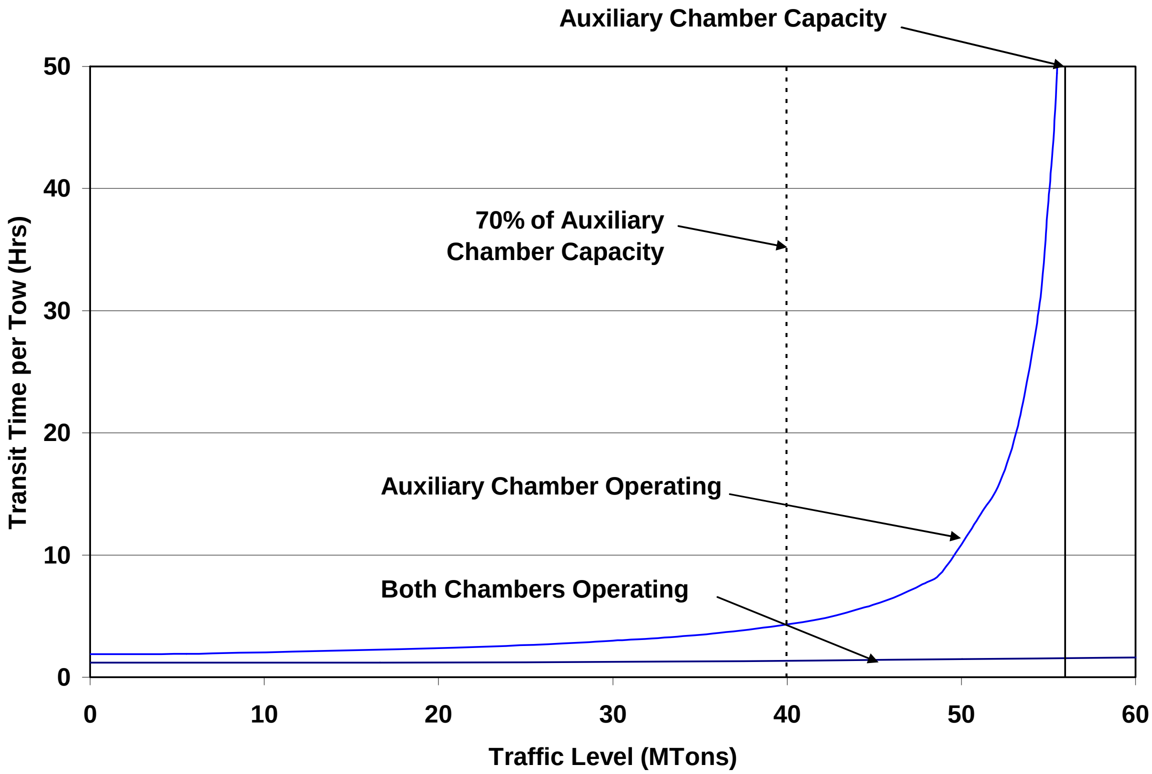


Chart C-3 focuses on the part of **Chart C-2** below 60 million tons. It shows the traffic-transit time curves for both chambers operating and only the auxiliary operating. With only the auxiliary operating, transit time rapidly increases as traffic levels exceed 40 million tons. At 40 million tons, which is 70% of the auxiliary chamber capacity, average transit time with only the auxiliary operating is 4.7 hours. On the other hand, transit time is only 1.4 hours per tow if both chambers are in service. Stated another way, the transit time with only the auxiliary chamber operating is equal to that for both chambers operating ***multiplied*** by 3.4. Hence the term impact severity multiplier.

Figure C-3



Caveat: The traffic-transit time curves for the auxiliary chamber, shown in **Figures C-2 and C-3,** were developed for a condition where the main chamber was closed for an entire year. Until a procedure is developed for incorporating closure duration into this analysis, those curves are the best available.

Using the logic of comparing transit times with and without the main chamber operating, **Table C-1** shows the closure impact severity multipliers at various points along the auxiliary chamber curve. Note that the final multiplier was calculated at 99% of capacity. This value is used because the capacity curve is almost vertical at traffic levels greater than 99%, which causes the multiplier to be excessively large.

Table C-1

Demand/Aux Capacity	Multiplier	Average for Range
0%	1.6	
		2.5
70%	3.5	
		4.0
80%	4.4	
		6.9
90%	9.4	
		14.0
95%	18.5	
		32.4
99%	46.4	

At this point, reasonably valid multipliers have been developed for multi-chamber locks where the demand is less than or equal to the capacity of the auxiliary chamber. **Caveat:** The first time this procedure is applied, it may be wise to test several multipliers to determine whether overall project ranking is sensitive to these multipliers.

What about those locks where demand exceeds auxiliary chamber capacity and what about single chamber locks? **Caveat:** Unfortunately, as of the date of this standard, no valid method has been developed to generate multipliers for these situations. Therefore, we must use reason and professional judgment as tools to estimate these multipliers.

Reason indicates that when demand exceeds capacity, some traffic will have to divert. It's a simple fact that all traffic cannot be served. Reason and experience tell us that it will be more expensive to find an alternative shipping mode on short notice than it would be if one had the leisure of negotiating a long term contract. Reason and professional judgment also tell us that some shippers may not be able to find alternate shipping arrangements at any cost. This occurred during the scheduled closure of McAlpine in 2004. One company was unable to find suitable alternate arrangements. As a consequence, that company shutdown a plant which will never reopen. Based on the discussion above, and lacking any better data, it may be reasonable to assume the impact will be 50% greater than that experienced when demand equals 99% of capacity. This means the multiplier will be about 70. **Caveat:** The first time this procedure is applied, it may be wise to test several multipliers to determine whether overall project ranking is sensitive to this multiplier.

Concerning single chamber projects, we must again use reason and professional judgment. Reason and experience tell us that an unexpected closure at a single chamber facility has the greatest impact severity of any closure type. If a lock has an auxiliary chamber, most if not all of the traffic will be able to transit the lock. Granted, it may be severely delayed, and some may be diverted, but most traffic will be able to get past the lock. However, if an unscheduled closure occurs at a single chamber lock, nothing will move. Nothing can pass through that lock until it reopens. All shippers will be put in the position of looking for alternative shipping arrangements. The opportunity for finding alternative arrangements will be hindered due to the high short term demand. Given all these issues, it may be reasonable to assume the impact will be about twice as severe as the impact at a facility where demand exceeds capacity. This means the impact multiplier will be in the range of 140. **Caveat:** Again, the first time this procedure is applied; it may be wise to test a range of multipliers to determine whether overall project ranking is sensitive to this multiplier.

5. Economic Performance Measures. The economic performance measure is the third important issue that must be incorporated into this Standard. There any several potential performance measures available. Some are more valid for measuring economic impact than others.

a. Transportation Rate Savings. Probably the best and most defensible measure available when this Standard was written is transportation rate savings. Transportation rate savings is the transportation rate difference between shipping commodities using the navigation system for at least part of the trip versus shipping commodities via the least costly all-land route. Transportation rate savings is calculated for every lock in LRD by the PCXIN in Huntington, WV, so the measure is readily available. **Caveat:** It is recognized that transportation rate savings is determined by analysis of long term transportation rates that shippers are able to secure through negotiation. Unexpected closures will potentially cause shippers to seek transportation services at "spot market" prices which may be significantly different than long term prices.

b. Commodity Tonnage. This measure is readily available from both OMNI data and Waterborne Commerce Statistics data. When this Standard was written, tonnage was used as a performance measure by Corps Headquarters. Therefore, for sake of consistency with nationwide performance measures it is included here as a potential measure. **Caveat:** The tonnage passing through a lock is, at best, an indirect measure of the economic value of the lock.

c. Ton-Miles. This is another measure used by Corps Headquarters as a performance measure. This is another readily available measure obtainable from Waterborne Commerce Data. **Caveat:** The ton-miles of traffic through a lock is, at best, an indirect measure of the economic value of the lock.

d. Other impacts. This category of impacts may include things such as the value added to the economy by the commodities shipped through a facility, i.e. coal used to create electricity which is used for other purposes. It may also include other economic impacts not listed here. These impacts are not generally available, but they are included here because we recognize there may be other legitimate measures available in the future.

6. Normalization of Impact Indicator Values. The impact indicator values produced by multiplying the probability of failure by the impact severity multiplier by the economic performance measure will likely produce very large numbers. For the sake of simplicity and clarity, it is advisable to normalize these impact indicator values. Also, if the PCXIN and LRD Chief of Operations decide to use more than one performance measure to gauge the impact of potential unscheduled closures, it becomes necessary to normalize the impact indicator values. For example, if one was going to use transportation rate savings and tonnage as measures, transportation rate savings is expressed in dollars and tonnage is expressed in tons. Also, as a matter of scale, transportation rate savings will likely be 10 to 20 times larger than tonnage. In order to give each measure equal weight, and remove the issue of differences in unit measures, they must be normalized.

One way to normalize these indicator values is to develop an index number for each measure that varies between 0 and 10.

The largest impact index value for each measure would be given an index of 10. Those with an impact indicator value ½ the maximum would be given a normalized index value of 5, and so forth. If multiple performance measures are used, they can be averaged to derive an impact index value that gives each measure equal weight, or they can be combined giving one measure more weight than the other.

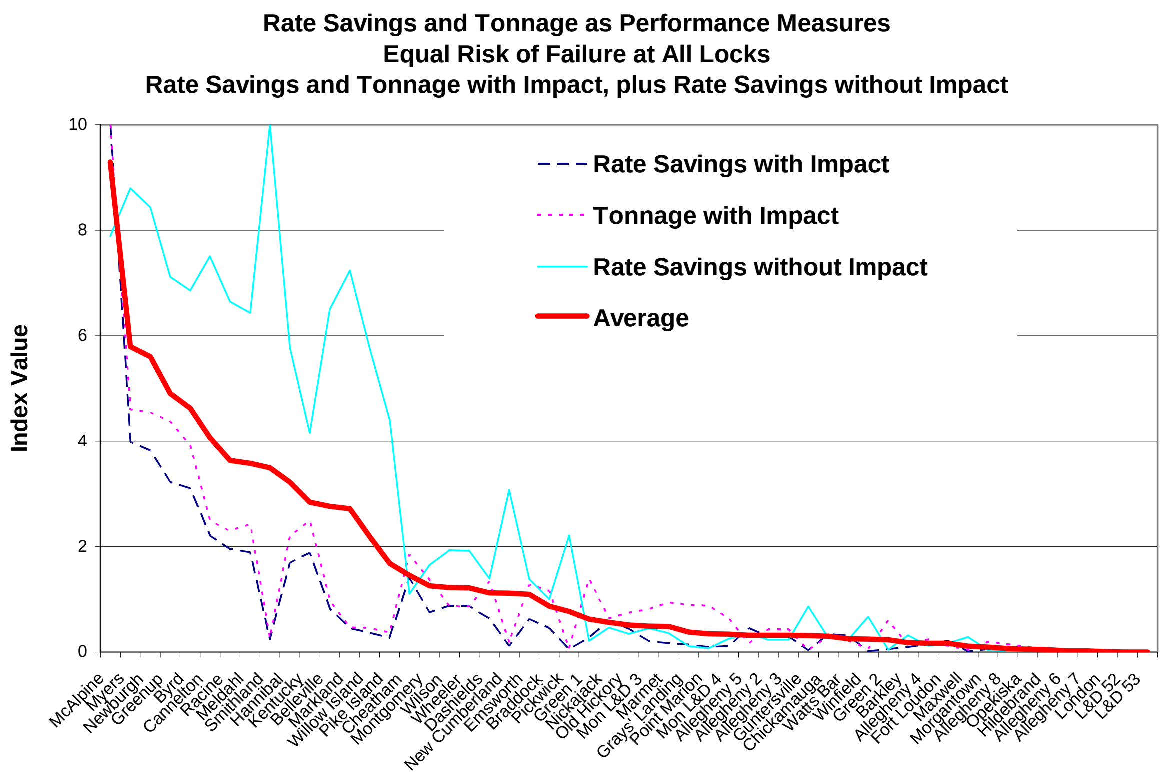
7. Division Baseline Impact Curve Description and Development. The Division Baseline Impact Curve is composed of normalized impact index values. Appendix A, sections 2b and 2c describe how this curve will be used as a guide for selecting the frequency of dive inspections and dewatering inspections.

8. Example Division Baseline Impact Curve. **Figure C-4** shows the Division Baseline Impact Curve created during development of this guidance. It shows four curves.

a. A tonnage based curve including impact severity
b. A system rate savings based curve including impact severity
c. A system rate savings without impact severity, and
d. The average of the three.

The curves were created using equal risk of failure estimates and the impact severity multipliers shown in **Table C-1**. It should be noted that after risk factors are applied, the relative ordering of projects could change significantly. Also note that Locks and Dams Nos. 52 and 53 are not included in the analysis. These projects were excluded due to the complexity of these projects operating in navigable pass mode part of the year and locking mode the remainder of the year.

Figure C-4



Rate Savings and Tonnage as Performance Measures
Equal Risk of Failure at All Locks
Rate Savings and Tonnage with Impact, plus Rate Savings without Impact
Index Value
10
8
6
4
2
0
Rate Savings with Impact
Tonnage with Impact
Rate Savings without Impact
Average
McAlpine
Myers
Newburgh
Greenup
Byrd
Cannelton
Racine
Meldahl
Smithland
Hannibal
Kentucky
Belleville
Markland
Willow Island
Pike Island
Cheatham
Montgomery
Wilson
Wheeler
Dashields
New Cumberland
Emsworth
Braddock
Pickwick
Green 1
Nickajack
Old Hickory
Mon L&D 3
Marmet
Grays Landing
Point Marion
Mon L&D 4
Allegheny 5
Allegheny 2
Allegheny 3
Guntersville
Chickamauga
Watts Bar
Winfield
Green 2
Barkley
Allegheny 4
Fort Loudon
Maxwell
Morgantown
Allegheny 8
Opekiska
Hildebrand
Allegheny 6
Allegheny 7
London
L&D 52
L&D 53